



A Matter of Choice: Opportunities for Informal Science Institutions to Support Science Teacher Induction

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ABSTRACT

Teacher induction programs are an important investment in supporting novice teacher development and retention in the classroom. Effective induction support for beginning science teachers should address content-specific understanding and needs that are differentiated from other subjects. Informal science institutions that have unique resources distinct from schools and districts can attend to some of these science-specific needs in a way that complements and supplements the support provided by formal systems. This article describes a 2-year induction program for secondary science teachers provided by an informal science institution in California and explores how the program supported critical areas of understanding needed by new science teachers. Graduates of the program reported access to science content expertise and a community of like-minded science teachers as essential supports to their induction that added to their supports from district-based programs.

KEYWORDS

induction program; informal science institutions; professional development; secondary science teachers

A common headline when the school year begins each fall is the shortage of classroom teachers. This is particularly prevalent for science and math classrooms in hard-to-staff areas. A careful look at the trends in teacher staffing across the country reveals that the problem is not a lack of teacher supply, rather that features of the organization of schools make it difficult for teachers to stay in the profession (Ingersoll & May, 2012; Ingersoll & Perda, 2010). The recent report by the National Academies of Sciences, Engineering, and Medicine (NASEM) on science teacher learning and the Next Generation Science Standards similarly highlighted the need for districts and schools to better organize support for science teachers' learning across their careers (NASEM, 2015).

One way that districts and schools have worked to retain teachers is through the use of induction programs. Induction programs are designed to support beginning teachers with the myriad of challenges that emerge in their first few years of teaching. Teacher induction programs can follow a variety of formats and provide a range of supports from 1-day orientations to year-long support through peer mentoring, classroom coaching, and professional development workshops (NASEM, 2015). Furthermore, multiyear programs can give attention to the differing needs of teachers in their first versus second years (Luft et al., 2011). Research on the effects of

induction programs highlights the importance of multiple facets of support for new teachers as they navigate their new careers (Ingersoll & Strong, 2011).

Teachers learn across many contexts both in and out of their school settings. Although informal science institutions (ISIs) have been pursued as an important context for pre-service teacher learning (McGinnis et al., 2012) and professional development for mid-career teachers (Phillips, Finkelstein, & Wever-Frerichs, 2007), researchers have yet to explore ISIs as a resource for science teacher induction. In this article, we consider the variety of supports needed by new secondary science teachers and how these needs might be addressed by an ISI. First we review the literature on the needs of new science teachers and the research on induction programs geared toward attending to those needs. Then we present a framework for learning science in informal settings and a review of the literature on the role of ISIs in science teacher learning to better understand how these informal settings might support beginning teachers through their induction years.

Background literature

Needs of beginning science teachers

Although most new teachers struggle with issues related to organizing their learning environment and developing as a professional, beginning science teachers have specific needs related to science content and pedagogical content knowledge that can present significant challenges during their induction period (Davis, Petish, & Smithey, 2006). For example, beginning science teachers are rarely hired to teach content that aligns with their degree (Banilower et al., 2013). Many secondary science teachers have undergraduate degrees focused on one of the specific science disciplines and have spent a number of years developing content expertise in that field. When teachers teach out of their content expertise, they have to learn science content alongside the knowledge and practices they need to manage and organize their students' learning. Furthermore, if beginning teachers are working outside of their content area, they may have a harder time enacting the student-centered teaching practices they learned in their preservice program, relying more heavily on lecture and discussion (Saka, Southerland, Kittleson, & Hutner, 2013).

Even when teaching familiar content, beginning science teachers often revert to traditional teaching methods in the face of the challenges that emerge as they take on their own classrooms (Roehrig & Luft, 2004). Science teachers have rarely learned science in the ways that they are expected to teach it (McDermott & DeWater, 2000). The Next Generation Science Standards and the National Science Education Standards that preceded them both emphasize inquiry and engaging students in the practices of science (National Research Council, 1996; NGSS Lead States, 2013). Most science teachers have learned content in traditional settings, in which instruction is typified by lectures, reading from textbooks, and performing cookbook lab experiments that confirm the information they receive from their teacher or reading of the text. Beginning teachers need regular experiences with and resources for trying out new and innovative teaching practices (Luehmann, 2007). In their preservice program, they likely have one opportunity to teach a lesson and rarely have the ability to reflect, revise, and try that lesson again. On becoming independent classroom teachers, they want to be seen as competent and

effective, which can lead to less risk taking and fewer opportunities to try unfamiliar teaching practices (Saka et al., 2013).

Along with possibly having to learn the content they are assigned to teach and new ways for teaching that science content, novice science teachers need to understand how their students will develop understanding of this new content (Davis et al., 2006). Students vary in their experiences in and out of school from one another and likely from their teacher. These differences can have profound effects on how they learn science (Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001). New science teachers need support in understanding both how students' ideas develop over time and how that might vary across different groups of students and science disciplines.

Science teacher induction programs

Research on induction programs for science teachers has highlighted the need for science-specific supports (Luft, Roehrig, & Patterson, 2003). The broad base of understanding needed by novice science teachers described previously requires various forms of standards-based support that can address the needs of beginning teachers beyond their preservice training (Roehrig & Luft, 2006). Further work is needed to understand how novice teachers build their competency in these areas, which is impacted greatly by their environmental contexts and initial classroom experiences (Luft, Dubois, Nixon, & Campbell, 2015). Few examples of science-specific induction programs have been documented in the literature, and we explore one such program here.

The Alternative Support for Induction Science Teachers (ASIST) program was created to address the needs of beginning secondary science teachers in southern Arizona using three design premises: the need for long-term, ongoing support; the inclusion of constructivist lessons to support the development of science and science teaching knowledge; and a collaboration between a university, a school district, and teachers (Luft & Patterson, 2002). The ASIST program had a science-specific focus and utilized university science education staff to provide model lessons and workshops that supported participants' understanding of science instruction and learning environments. A project listserv and conference participation were included to support beginning teachers' development of professionalism. A comparison study was conducted to determine the impact on teachers' practices and beliefs of participating in ASIST versus general, district-based induction programs versus no formal induction program at all (Luft et al., 2003). The district-based induction programs were typically generalized in content and grade level and offered beginning teachers support with learning environments. Teachers who received science-specific support through ASIST demonstrated more student-centered and inquiry-oriented practices in the classroom and did not report constraints to their instruction expressed by their peers. This finding underscores the importance of content specificity in supporting novice science teachers' understanding and development.

The ASIST program also gave beginning teachers access to mentoring from experienced teachers in their field (Luft & Patterson, 2002). Opportunities for collaborative reflection with mentors can support science teachers' understanding of science content and science learners while establishing a professional culture of continued growth with one's peers (Luft et al., 2015; Nam, Seung, & Go, 2013). Networks of peers with different levels of experience can help develop professionalism in beginning teachers that exists

beyond their department and schools (Fox & Wilson, 2009). Given the breadth of understanding identified as required of beginning science teachers, programs should be designed in a way that identifies and capitalizes on the strengths of different support providers to provide comprehensive induction for novice teachers.

Theoretical framework

Informal science learning

Given the consensus that beginning science teachers require significant support grounded in science content, we look to understand how ISIs as a community might provide beginning teachers with resources for that learning. We take the perspective that learning is socially situated and happens through participation in communities (Wenger, 1998). These communities are organized around mutual goals and progress toward those goals is mediated by shared resources and tools (Cole, 1996). We present a framework for understanding how learning in informal contexts is organized and mediated toward goals for public understanding and participation in science to ground what teacher professional learning might look like in informal contexts.

Learning in informal settings is generally defined as self-motivated, voluntary, directed by the interests of the learner, and cumulative over a lifetime (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003). Although informal contexts can include anything from watching films and reading books to participating in bird-watching clubs and visiting museums, we focus on designed informal learning environments (National Research Council, 2009), primarily ISIs, as a site for beginning science teacher learning. ISIs encompass museums, zoos, aquaria, and botanical gardens. These settings are structured for independent learning and generally reflect the goals of the institution. Similarly, these settings are designed with multiple pathways and entry points so that visitors can freely choose how and with which exhibits they interact. In this way, participants have control over their learning and participate at their own pace. Last, learning experiences in ISIs intentionally incorporate designs that evoke emotions of surprise, awe, and joy, which can have important consequences for interest and learning in science (National Research Council, 2009). In the next section, we review the literature on teacher learning in ISIs to understand how these programs have been used to support science teacher learning.

ISIs and teacher professional learning

A review of the literature on science teacher learning in ISIs reveals a focus on preservice education and professional development for midcareer science teachers. ISIs are used in preservice education as sites for clinical practice and exposure to science learning in out-of-school contexts (McGinnis et al., 2012). ISIs provide professional development for a range of in-service science teachers from elementary to secondary teachers and generally focus on supporting science teachers in learning science content and having access to resources for their classrooms (Phillips et al., 2007). Regardless of when and for what purpose science teachers are introduced to ISIs as a resource for their learning, there is considerable evidence of the benefit of seeing and experiencing science learning in informal settings on science teacher learning.

Informal settings, such as after-school programs and museums, have been used as practicum sites in preservice teacher education (Avraamidou, 2014; Luehmann, 2007; McGinnis et al., 2012). A review of the literature on informal settings in preservice teacher education highlights the benefits of such programs, which include positive attitudes toward science, practice trying out new pedagogies, increased understanding of science, and development of professional skills (McGinnis et al., 2012). However, the reviewers also point out limitations of the use of informal settings in preservice education, including translating experiences from informal to formal educational contexts. Continued professional experiences as an in-service teacher might ameliorate some of these challenges and support teachers in continuing to use and develop teaching pedagogies from informal settings.

ISIs have been shown to provide significant support for in-service science teacher learning through professional development, curriculum support, and field trips (Phillips et al., 2007). Teachers have reported that museum-based professional development programs are more productive and informative than other professional development opportunities provided to them (Melber & Cox-Petersen, 2005). They have highlighted the importance of access to science expertise, to other science teachers, and to opportunities to engage with science in hands-on ways through museum exhibits as important to their professional development experience in museums.

An extensive survey of ISIs was conducted by Phillips et al. (2007) to determine how these institutions support formal science learning. Their initial survey found that 59% of the ISIs that responded provided some form of professional development for science teachers. In a follow-up survey of those institutions, they found that the professional development provided by ISIs involved engaging teachers in activities that they could then use with their students or sharing curricular resources they could use from the ISI. Furthermore, the majority of respondents reported that the main goal of their professional development was to support teacher development of science content understanding.

An interview study of ISI professional development providers similarly found that professional development in ISIs was characterized by teachers engaged in activities as science learners, in which facilitators modeled pedagogy that teachers could use in their classrooms (Astor-Jack, Balcerzak, & McCallie, 2006). This modeled pedagogy included teachers' active learning through inquiry-based activities in which teachers asked questions, planned and carried out investigations, and took part in discussions about observations connected to life experiences. These providers also highlighted the importance of teacher input, free choice, and a safe environment for teachers to learn, which correspond to design features that support learning in informal science settings as described previously.

One novel feature of ISIs and museums in particular is the exhibits that are designed specifically to convey science content understanding. Professional development providers in ISIs have reported the use of exhibits in support of science teacher content learning (Astor-Jack et al., 2006). However, the use of exhibits in teaching is not always accompanied by reform-based teaching practices. For example, one study found didactic use of museum exhibits when teachers were engaged in science content learning in these spaces (Holliday, Lederman, & Lederman, 2014). Regardless, teachers had more content-rich discussions at exhibits when their experience was facilitated in some way.

The research on science teacher professional learning points to important resources for new science teachers, including access to science experts, opportunities to engage as learners of science content, and connections to other science teachers. Similarly, research highlights how the unique features of ISIs can support teachers in directing their professional learning and gaining emotional benefits from engaging in informal science learning. However, there are little to no reported programs or research on professional development opportunities specifically for beginning secondary science teachers in ISIs (Phillips et al., 2007). In this article, we analyze how an induction program housed in an ISI might provide professional supports for beginning teachers during their first few years as science teachers. We analyze data from a survey and follow-up interviews with participants in the induction program to answer the following research questions:

- (1) How does the ISI induction program support critical areas of need among beginning science teachers?
- (2) How do choice and the self-directed nature of the ISI induction program support beginning teachers in addressing their specific induction needs?

Methods

In this section, we first describe the induction program and how participants self-select and participate in the program in their first few years as a classroom science teacher. Then we describe the data collection tools and methods and end with a description of how the data were analyzed.

Study context

Science Center Teacher Institute (TI) is a professional learning center housed in an ISI that offers comprehensive, multiyear professional development institutes, classroom coaching, peer support groups, and teaching tools to secondary science teachers. Programs are differentiated, as well as intentionally blended, for novice, experienced, and leadership-level teachers, thus providing professional learning opportunities at all points of the teacher learning continuum. Since its inception in 1984, TI has utilized a staff of PhD scientists and veteran secondary science educators who work in concert to provide teachers with resources and experiences that develop the content knowledge and pedagogical skills necessary for teaching authentic science content through student-centered, inquiry-oriented activities (McDermott & DeWater, 2000). Participants are invited to return for the rest of their careers, which has resulted in a growing community of more than 3,000 teachers. By providing continual science-specific professional development delivered by a stable, experienced staff, TI has sought to provide teachers with a network of support that complements and supplements what is provided by their schools and districts (NASEM, 2015).

In 1998, in response to increasing numbers of novice teachers and their low retention rates, TI created two intentionally overlapping programs: (a) the Teacher Induction Program (TIP), the nation's first science-specific beginning teacher program; and (b) the Teacher Leadership Program. TIP provides participants with a menu of support options

suited to the unique needs of novice science teachers from which an individualized program can be created. The Teacher Leadership Program leverages the expertise of TI's alumni pool and trains science teachers with at least 5 years of classroom teaching experience to serve as mentors and coaches for the novices.

Science teachers apply to the program in their first or second year of teaching in formal classrooms. Every year, 25 science teachers are accepted into the 2-year program. Once accepted, teachers receive 2 years of classroom support through coach observations that occur twice a semester and monthly mentor meetings that happen outside of school time with a small group of novice teachers and two or three experienced classroom teachers who serve as mentors. The novice teachers also participate in four content-based workshops and four pedagogy workshops of their choice at the science center on Saturdays throughout each academic year and a 3-week summer institute that takes place after their first year of classroom-based support.

Data collection

The data for this analysis were collected in two stages. In the first stage, we surveyed participants in TIP to identify how they perceived the supports they received in the program. Based on responses to that survey, we followed up with respondents and invited them to participate in a more in-depth interview about their participation in the program. We describe both phases of data collection and analysis here.

Survey design

We surveyed graduates of the TIP program in order to explore the ways in which an induction program through an ISI supported the needs of new science teachers. The first part of the survey asked TIP graduates about their professional status, whether they were currently teaching science in kindergarten–Grade 12 (K–12) settings, and the subjects and type of school in which they taught. Respondents who were not currently teaching in a K–12 classroom were directed to a set of questions about their current profession and how long they had previously been in the classroom. The bulk of the survey was designed to ask graduates to report on how often they felt they received support in five critical areas identified in a review of the literature on beginning science teachers (Davis et al., 2006). These critical areas were an understanding of science content and the discipline of science, science learners, science instruction, learning environments, and professionalism.

We included two open-ended questions. The first appeared at the end of the 20-question section on how often participants felt supported in the five critical areas. The question read, “If you answered rarely or never to any of the questions above, would you have wanted to have more support in that area from the Teacher Institute? Please list those areas below.” This question was used to provide participants with the ability to respond with whether they needed TIP for those types of support. The second open-ended question asked respondents for any additional comments.

Sample

Paper records as well as a digital database were mined for contact information for all of the graduates of TIP. A total of 435 graduates were located in the system, and we sent each graduate an e-mail with a link to the survey and a brief description of why we were conducting the survey. Of the 435 e-mails that were sent, a total of 70 bounced back as undeliverable. We attempted to reach each of those graduates by phone and were able to locate current information for 20 of those individuals. Therefore, a total of 50 graduates of the program did not receive the survey because of a lack of current contact information. We sent out another e-mail to all of the graduates for whom we had contact information and who graduated from the program before 2015 ($n = 385$). A total of 143 graduates of the program completed the survey (response rate = 37%). Teachers were grouped into 3-year cohorts based on the year they began the program, and respondents from each cohort were represented (see Table 1).

Follow-up interviews

In analyzing the survey data, we found that respondents pointed to the importance of the science-specific supports of TIP and the gap that the program filled in their overall induction support in their first few years as a science teacher. In order to better understand this pattern in the survey data, we contacted respondents for follow-up interviews. The semistructured interview was designed to elicit information about interviewees' first years as a science teacher, what they felt prepared and unprepared for as a new teacher, the types of induction support provided by their school or district, their participation in TIP, and how the different modes of support attended to their various needs as a new teacher. We also asked them about their degree, the context of their first teaching job, and whether they were currently teaching science.

Sample

We contacted all of the original respondents of the survey and invited them to be interviewed over the phone. A total of 23 people responded to the request for interviews, and we conducted 15 phone interviews total. Two of the interviews were unusable because of inaudible recording or because the interviewee did not respond to all of the questions asked. This resulted in a total of 13 interviews analyzed for this study.

Table 1. Percentage of respondents from different cohorts of graduates ($n = 143$).

Year started program	Percentage of respondents
1998–2000	13
2001–2003	15
2004–2006	22
2007–2009	22
2010–2013 ^a	28

^aThere was no 2012 group, so to keep each cohort to three program years we added 2013.

Analysis

Survey

Data were aggregated across different categories to create a picture of the distribution of teacher responses for each statement, which were then sorted by critical need. In order to calculate retention rate, we included only respondents who graduated prior to 2010 ($n = 103$). From among the teachers who were not currently teaching in a K–12 setting, we calculated the number of teachers who reported teaching in a formal setting for at least 5 years.

Interviews

We created detailed content logs for each interview. Content logs were organized according to the questions asked in the interview process. Two researchers independently coded each of the content logs to identify (a) the resources participants described as part of their overall induction support, (b) the aspects of TIP that teachers described as the most helpful and unique aspects of the program, and (c) the compatibility of the different facets of teachers’ induction support. Table 2 provides the coding categories and examples from teacher interviews. Each researcher wrote research memos that summarized codes from each interview and then met and discussed their written memos and codes and adjudicated any differences.

Findings

Taken together, the responses to the survey and to interview questions highlighted the importance of participants’ access to science-specific supports and to a community of like-minded science teachers in TIP. Responses to the survey reflected the fact that participants felt that they had access to science content, activities they could use in their classrooms, and other science teachers more often than less science-specific supports like grouping students or communicating with parents. Interview data confirmed this finding and also revealed that these aspects of TIP augmented the other pieces of participants’ induction support provided by their district and/or school. We organize the findings according to our research questions, starting with how the TIP program addressed critical areas of need for beginning science teachers. Then we move to a discussion about how the nature of the informal learning environment supported participants in making choices about their induction needs.

Table 2. Descriptions of codes used to analyze interviews with Teacher Induction Program (TIP) participants.

Code category	Description
Resources	Interviewee discusses resources for his or her professional learning other than TIP. Examples include district induction program, mentor, other teachers, administrator, other professional development opportunities.
TIP	Interviewee identifies aspects of TIP that were the most useful for his or her practice. Examples include mentor meetings, coaches, Saturday workshops, summer institute, Science Center Teacher Institute staff, science activities, community of like-minded teachers, emotional support.
Compatibility	Rate how the interviewee talks about the fit of TIP with other aspects of his or her induction program: high, medium, or low.

Induction supports from TIP

In the survey responses, the statements that reflected the most frequent support for the beginning teachers related to learning science content (92% always or often) and having access to a community of like-minded teachers to learn from (84% always or often), followed by support in understanding how their students learn science (60% always or often) and instructional practices in science (60% always or often). The category that participants felt was least reflected in the program related to issues of their school environment, such as classroom management and communication with parents (38% always or often; see Table 3). The responses in each of these categories highlighted how TIP provided participants with science-specific support regularly throughout the program and not necessarily supports that related to their classroom learning environment or school climate.

Induction programs have been touted as important resources for retaining teachers in K–12 classrooms; therefore, it is important to understand whether participants in these programs stay in the teaching profession. Responses to the survey revealed the success of TIP participants in staying in the classroom and in participating in greater levels of leadership within their schools and districts. Of the respondents who graduated from the program before 2010 ($n = 103$), 91% taught for at least 5 years in a formal K–12 setting. Currently the majority of TIP graduates (73%) were still teaching in K–12 classroom settings. The other TIP graduates worked at the district or school administrative level (11%) or were working in higher education (6%) or in informal education (2%). A total of 3% of respondents were not in any kind of educational position, and 5% were currently on family leave or unemployed. Table 4 provides the breakdown of current professions of TIP graduates who responded to the survey.

Respondents were also asked about their engagement in professional practices as supported by their work with TIP. A total of 81% of respondents said that they had taken on leadership roles at their school, 73% had mentored other science teachers in their school or district, and 61% had provided professional development for their school or district colleagues (see Table 5).

Table 3. Average proportion of responses for how frequently participants received support in each of five categories of beginning science teacher challenges.

Category	Always	Often	Sometimes	Rarely	Never	Not applicable
Science content	52%	40%	7%	0%	0%	0%
Professionalism	49%	35%	14%	2%	1%	0%
Learners	25%	35%	29%	9%	2%	1%
Instructional practices	22%	38%	31%	8%	1%	1%
Learning environment	13%	25%	35%	18%	7%	1%

Table 4. Current professions of Teacher Induction Program graduates ($n = 143$).

Profession	Percentage of sample
Kindergarten–Grade 12 classroom teacher	73
School or district administrator	11
Higher education	6
Informal education	2
Unemployed	5
Noneducation field	3

Table 5. Professional activities of Teacher Induction Program graduates ($n = 143$).

Statement	Yes	No	Not applicable
I have taken on leadership roles at my school.	81%	18%	1%
I have mentored other science teachers at my school or district.	73%	27%	0%
I have led professional development at my school.	59%	41%	0%
I have led professional development in my district.	47%	52%	2%

Although the survey data highlighted the science-specific nature of TIP and the successful retention of teachers who participated in the program, we received little information about how TIP functioned as a support within the myriad of resources teachers had access to (or not) within their induction period. We turn to the interview data to better understand the scope of supports available to the new teachers in our program and the role of TIP within that network of support.

Analysis of interview data confirmed the importance of science-specific supports and access to a community of like-minded teachers in TIP. The interview data pointed to underlying mechanisms for how these aspects of TIP functioned within the myriad of available resources in teachers' induction support. These mechanisms related to features of the informal learning context, including the ability of participants to make choices about their induction supports and the presence of emotional connections to their learning. We start by presenting evidence of the nature of participants' induction support from their school or district. Then we demonstrate how choice and emotional support within TIP helped teachers to augment these school or district induction programs.

Induction support for TIP participants

Eleven of the 13 teachers interviewed stated that they had a variety of school and district resources available to them in their first few years of teaching. Only the two teachers who were in independent schools lacked specific induction supports from their schools. Supports included a district-appointed classroom coach, schoolwide professional development, and other colleagues at their school site. Most of the professional development provided for the teachers by the school or district related to literacy or math and student-specific issues such as diversity and differentiation. Overall these supports were more specific to participants' school site and provided them with a vision for teaching and learning at their school and in their individual classrooms.

All of the public school teachers ($n = 11$) spoke about their participation in a state-mandated and district-led induction program in their first 2 years as a classroom teacher. In this program, they were assigned a classroom coach who met with them regularly—this varied from weekly to monthly—to observe their instruction and help them build a portfolio of their teaching for the district and the state. Although most interviewed participants reported having a positive relationship with their district-appointed coach, they often noted that their coach did not have experience teaching science and would help them navigate the more general challenges of teaching:

I had a BTSA [state-mandated program] mentor who came to my classroom once a week and we did all the little BTSA tasks together. I had to go to a few district-wide or maybe county-related BTSA workshops. Those were mostly pretty useless but having a mentor work with

me every week was helpful. The things that we talked about were never about science she wasn't mainly helping me with science. (Interview T4)

Although this teacher discussed the fact that having a weekly meeting with her appointed mentor was helpful, she noted that the support was not science specific. She attributed her participation in TIP as integral to getting the science support she required:

I thought about my supports in categorical ways, I was doing [TIP] at the same time as I was working with BTSA. When I was thinking about classroom management or math or differentiation or broader subjects I would think about BTSA support. But [TIP] was more science-related support. I thought of them differently in my head. (Interview T4)

Choice and science-specific support in TIP

The science-specific supports available through TIP were regularly referenced in interviews, similar to responses in the survey data. It is interesting that the interviewees found content support in different ways. This is where we think choice is an important feature of the ISI induction program and supported teachers in making decisions about where to seek out the support that best suited their particular situation. For example, although 10 of the participants interviewed talked about the importance of access to science activities for their classroom, they referenced different aspects of the program as sources of those activities. These features of the program included the workshops at the museum (four respondents), the community listserv (two respondents), mentor meetings (one respondent), and TIP staff (three respondents).

For these 10 participants, the access to science-specific activities filled various gaps in their induction experience and their personal histories in science. These included gaps in content understanding, readily available activities, and experiences learning science through inquiry. For example, six respondents stated that their participation in TIP helped fill gaps in content knowledge and provided ideas for activities they could do in their classrooms:

Lots of science content. I thought that was great. Get lots of updates on current research and then you would have professors come and talk to you. That was really cool. I got a lot of content knowledge from [TIP], and they had a lot of good ideas for activities to do in the classroom. (Interview T9)

Seven of the interviewed participants specifically discussed the importance of access to science content and activities that they could translate to their classrooms and that this was different from the kinds of supports they were getting from their other induction programs:

There were many times that I went to a workshop and I would think "Okay this is what we're doing next." I was hungry for more curricular ideas my first year. New ways to think about things, experiment[s] to pick up at the supermarket, etc. (Interview T4)

Three of the interviewed participants pointed to the importance of having a space to try out activities before using them with their students. One of the challenges new teachers face is having to teach science in ways that they did not have an opportunity to experience as science learners. One interviewed teacher articulated how her experience in TIP gave

her that opportunity and that it was integral to her ability to use those practices in her classroom:

I did not learn science in the way that I taught it, and I don't think that I would have been able to teach it half as well had I not gone through TI. Had I not had that food for thought and the opportunity to explore and ask questions and make mistakes and be confused before trying to implement with my students. (Interview T12)

All three teachers discussed how important it was to them to be able to actively explore activities and have experiences as learners in TIP.

One interviewee discussed how the activities and resources she received at the science center helped her to complete requirements from the district-mandated induction program. As part of the district induction program, new teachers were required to create a binder of lessons, reflections, assessments, and other activities. For example, one teacher noted, "I remember like all the different pages I had to do for BTSA and [TIP] made that a lot easier because I had so many lessons that were already connected to the standards" (Interview T1). Similarly, another interviewee noted how the activities spiced up his curriculum, adding a layer of excitement and interest that were not evident in the curriculum materials he received in another professional development program: "So I think the [university] and [TIP] [professional development] complemented each other well because the [university] curriculum is kinda dry but effective and very well thought out. The excitement of discovery and this kind of stuff from [TIP] meshed well" (Interview T3). This finding is reflective of the integrated nature of the varying supports and the fact that a distributed induction network can be instrumental in supporting new science teachers in being successful in their first few years in the classroom.

Emotional support in TIP

Like the survey, the interview data demonstrated the importance of access to a community of like-minded teachers for beginning science teachers. The interview data helped us to understand how this community of teachers supported these beginning teachers in areas of critical need. Nine of the interviewed participants highlighted the fact that the access teachers had to a community of like-minded science teachers was integral to their learning in their induction years. This access to other teachers provided the new teachers with emotional and material supports as they navigated new classrooms, schools, and groups of diverse students. For example, one participant reflected that

[TIP] was like a support group for new teachers. None of my family or friends, nobody knows what you are going through unless you are a new teacher. It was nice to know that other people are going through the same thing. (Interview T2)

She discussed the emotional support TIP provided to her that other aspects of her community were not able to understand. Another teacher talked about not having like-minded colleagues at her school and about how the community of teachers in TIP helped her fulfill her need to connect with others:

I'm a very touchy-feely person so it was fun to be energized by other people. There were some chronically grumpy people but mostly everyone was excited to be there. We could talk about

our common struggles but also get energized and excited, which is something I really lacked at my school in my second year. (Interview T6)

Another participant interviewed shared how the community shared resources and ideas for their classrooms in her mentor group meetings:

[In mentor meetings] we rotated to different school sites depending on where the teachers were at, showing our classrooms around. We used to send topics that we wanted to discuss. It felt casual. There was structure, but it was a casual environment where we could share ideas and situations that were occurring in our classrooms. The mentor that year was really great, and I met a lot of teachers there who, after we left [TIP], we were still able to share lessons and ideas. (Interview T8)

Again, this teacher highlighted how the community of teachers was able to provide her with an opportunity to share ideas and problems of practice—and how that community persisted today.

Summary of findings

The results affirm that previously identified features of learning in informal settings, including self-direction and emotional connection to learning, can be leveraged for the development of beginning science teachers. Participants were able to decide on and access the features of a multifaceted program that felt most useful to them. A critical part of the designed learning environment is the program staff of PhD scientists and veteran teachers. Their combined expertise enables science-specific support in ways that are relevant to the classroom. The integration of these strengths is embodied in two ways identified as most useful by participants—physically, through activities that teach authentic science content and are practical for the classroom; and pedagogically, through the creation of a space in which teachers experiment and fully engage as science learners. Furthermore, engaging as a learner in interesting and exciting activities points to a culture of learning as the foundation of the program, which is enhanced by the community and joyful environment and demeanor of staff.

Discussion

These results support previous reports of the importance of content-specific support for beginning science teachers (Luft et al., 2003, 2011). The human, material, and environmental resources of ISIs enable a model of professional learning that can specifically target opportunities for science-specific support. The staff and focus of the ISI program provided science content expertise that was not present in the school and district-based induction supports. Moreover, the active science learning opportunities provided within the context of the ISI allowed beginning teachers to acquire science content knowledge and engage with science and engineering practices through a pedagogy they were asked to use with their students but had seldom been exposed to in their own education.

The capacity of ISIs to focus specifically on science teachers also facilitates the creation of a network of teacher support with a greater number of peers with similar teaching scenarios than individual schools and districts. Furthermore, access to this network of science teachers lasted beyond teachers' participation in TIP. Teachers were able to seek

out continued support through a museum-managed listserv and access to workshops, other teachers and staff, and the museum itself beyond their participation in TIP. This continued support of a network of like-minded teachers has been highlighted as necessary to sustained use of an inquiry-based curriculum and reform-based science teaching (Kelly, 2000). By existing outside of the formal system, an ISI can sustain this network throughout a teacher's career, even as he or she switches schools or has a change in faculty or administration.

In terms of the five critical areas of understanding for beginning science teachers, ISI-based programs are thus poised to supplement existing school and district-based induction support by providing focused support in science content, professionalism (through community), and science instructional practices that can complement general induction support from other sources that may be more focused on learning environment and professionalism that is school or student oriented and content agnostic. A recent report by NASEM (2015) highlighted the importance of a network of support for science teachers across informal and formal contexts. Our findings further support this assertion, as teachers were able to fill in the gaps in their formal induction program by participating in TIP. Research on the comprehensive nature of teacher induction and the effect on teacher retention, job satisfaction, and classroom teaching practices is varied, and the field does not have a clear understanding of how a network of induction might support new teachers (Ingersoll & Strong, 2011). This study suggests that a network of support across informal and formal contexts might provide greater resources for new teachers in their first few years of teaching. Further research is necessary to understand which aspects of various induction programs provide this greater level of support and how they articulate with one another to better understand the comprehensive nature of induction.

It is important to note that respondents reflected on the compatibility of TIP with their school environment, which manifested through like-minded colleagues, school culture, and administrative support. Almost all novice teachers in the program received induction support from more than one source, and all had to implement their practice within the context of their individual school environments. This underscores the need for intentional coherence to be structured between these supports as much as possible. This requires communication and collaboration between providers of induction support and can be amplified by leveraging a network of teachers who have received and continue to contribute to that model of support. Recent research into efforts to develop partnerships between researchers and school districts (Penuel, Coburn, & Gallagher, 2013) could be helpful in thinking about how to best initiate and maintain collaborations between parties with mutual objectives in supporting the retention of new teachers in science classrooms.

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